BRIEF COMMUNICATION

Breast Cancer Mortality Among Female Radiologic Technologists in the United States

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We evaluated breast cancer mortality through 1997 among 69 525 female radiologic technologists who were certified in the United States from 1926 through 1982 and who responded to our questionnaire. Risk of breast cancer mortality was examined according to work history and practices and was adjusted for known risk factors. Breast cancer mortality risk was highest among women who were first employed as radiologic technologists prior to 1940 (relative risk [RR] = 2.92, 95% confidence interval [CI] = 1.22 to 7.00) compared with risk of those first employed in 1960 or later and declined with more recent calendar year of first employment (*P* for trend = .002). Breast cancer mortality risk increased with increasing number of years of employment as a technologist prior to 1950 (*P* for trend = .018). However, risk was not associated with the total number of years a woman worked as a technologist. Technologists who first performed fluoroscopy (RR = 1.69, 95% CI = 1.02 to 3.11) and multifilm procedures (RR = 1.87, 95% CI = 1.04 to 3.34) before 1950 had statistically significantly elevated risks compared with technologists who first performed these procedures in 1960 or later. The high risks of breast cancer mortality for women exposed to occupational radiation prior to 1950 and the subsequent decline in risk are consistent with the dramatic reduction in recommended radiation exposure limits over time. [J Natl Cancer Inst 2002; 94:943–8]

High-dose ionizing radiation has been associated with increased breast cancer risk among Japanese atomic bomb survivors *(1–3)* and among patients who have received radiotherapy *(4),* fluoroscopy, or repeated diagnostic x-rays *(5–7).* However, limited data exist regarding breast cancer risks among healthy women who have had chronic radiation exposures at low to moderate doses. For example, although cancer risks have been extensively evaluated for men who work in the nuclear industry *(8,9),* accurate estimates of breast cancer risk among women who work in the nuclear industry are difficult to calculate because relatively few women are so employed and those that are have very low radiation exposures *(10).* However, medical radiation workers, who constitute 44% of all radiation workers in the United States and include a high proportion of women, provide a unique opportunity to study breast cancer risks in a healthy population that has chronic exposure to radiation *(11–13).* In the present investigation, we studied 69 525 questionnaire respondents of the 106 884 women in a cohort of 146 022 U.S. radiologic technologists who were certified from 1926 through 1982. Compared with earlier reports on the U.S. radiologic technologist cohort *(14,15),* the present analysis added 7 years of follow-up, used more precise exposure surrogates, and evaluated potential confounding factors not previously examined in analyses of mortality.

Technologists were eligible for this study if they were certified by the American Registry of Radiologic Technologists (ARRT) for at least 2 years from 1926 through 1982 *(15,16).* Of the 106 884 female technologists who met the eligibility requirements, approximately 17 000 who were inactive registrants as of 1982 were traced using state and national databases *(16).* Current addresses were available for active registrants through annual recertifications with the ARRT. Deaths were identified through linkage with Social Security mortality files or the National Death Index; causes of death were obtained from death certificates or from the National Death Index *Plus* and were coded according to the International Classification of Diseases *(17).* A self-administered questionnaire was sent to the 99 234 female technologists who were known to be living and for whom a current address was available to ascertain their lifetime work histories, reproductive and family cancer histories, and other lifestyle factors *(16).* There were 69 525 respondents to the questionnaire. General characteristics and mortality rates were similar among respondents and nonrespondents *(16).* This study was approved by the Institutional Review Boards of the National Cancer Institute and the University of Minnesota.

Person-years of follow-up were compiled from the date of questionnaire completion to the date of death, last known vital status, or January 1, 1998, whichever occurred first. A total of 860 022 person-years were accumulated. Poisson regression *(18)* was used to estimate the relative risk (RR) of breast cancer mortality in relation to work history while adjusting for other covariates in the regression model. Analyses were stratified by attained age (a time-dependent variable representing age at each calendar year during the follow-up period) in 5-year age groups, calendar year of follow-up in 5-year categories, and race. Risks were calculated for the total number of years each subject worked as a radiologic technologist and the number of years each

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See "Notes" following "References."

Table 1. Relative risk* (RR) and 95% confidence interval (CI) of breast cancer mortality (with number of deaths) by year first worked, duration of employment, and number of years worked in different time periods as a radiologic technologist among 69 451† female respondents to the questionnaire

Year first worked	Total No. of years worked			P_{trend}‡	All years worked
	<10	10–19	≥20		
1960 or later					
RR (95% CI)	1.00§	1.15 (0.76 to 1.73)	1.48 (0.81 to 2.69)	(.38)	1.00‖
P value¶		.520	.203		
No. of deaths	42	57	17		116
1950–1959					
RR (95% CI)	1.71 (0.92 to 3.18)	1.29 (0.65 to 2.55)	1.26 (0.67 to 2.38)	(.10)	1.24 (0.77 to 2.00)
P value¶	.091	.471	.477		.375
No. of deaths	30	18	27		75
1940–1949					
RR (95% CI)	3.15 (1.38 to 7.18)	3.49 (1.49 to 8.18)	2.02 (0.88 to 4.62)	.84	2.44 (1.26 to 4.75)
P value¶	.006	.004	.098		.008
No. of deaths	16	13	16		45
1939 or earlier					
RR (95% CI)	0.77 (0.09 to 6.36)	5.55 (1.96 to 15.71)	2.98 (1.05 to 8.44)	.38	2.92 (1.22 to 7.00)
P value¶	.806	.001	.040		.016
No. of deaths	1	9	9		19
P_{trend}‡	(.003)	(.003)	(.003)		(.002)
All time periods					
RR (95% CI)	1.00‖	1.08 (0.80 to 1.45)	0.91 (0.65 to 1.29)	(.38)	
P value¶		.625	.607		
No. of deaths	89	97	69		255

Calendar period of employment#	No. of years worked in each calendar time period			P_{trend}‡
	0	1–4	≥5	
1949 or earlier				
RR(95% CI)	1.00	2.17 (1.20 to 3.95)	2.08 (0.94 to 4.61)	.018
P value¶		.011	.071	
No. of deaths	37	35	29	
1950–1959				
RR (95% CI)	1.00	1.18 (0.75 to 1.85)	1.08 (0.62 to 1.87)	(.81)
P value¶		.47	.79	
No. of deaths	57	67	63	
1960–1969				
RR (95% CI)	1.00	1.06 (0.70 to 1.60)	0.97 (0.61 to 1.52)	(.66)
P value¶		.78	.88	
No. of deaths	63	79	106	
1970 or later				
RR (95% CI)	1.00	0.75 (0.48 to 1.17)	0.76 (0.53 to 1.09)	(.172)
P value¶		.198	.137	
No. of deaths	81	34	143	

*All RRs were stratified for race, attained age, and calendar year of follow-up and were adjusted for age at menopause, age at first birth, and family history of breast cancer. The analysis for all years worked was adjusted for the duration of employment, and the analysis for all time periods was adjusted for the year of first employment.

†The questionnaires of 46 respondents contained insufficient information for analysis and were excluded. Subjects who reported that they were 65 years of age or older at menopause (one breast cancer death and seven women without breast cancer) or who reported first working when they were younger than 10 years old (20 women without breast cancer) were excluded from all analyses. Women with missing values for the year first worked and/or the number of years worked (23 women without breast cancer) and women who never worked as a radiologic technologist (5 breast cancer deaths and 1052 women without breast cancer) were included in this analysis and were coded as separate categories (estimates for these women are not shown in the table).

‡P for trend was based on the slope of the corresponding continuous variable; parentheses indicate negative slope estimates.

§Referent group for the joint analysis of the number of years worked and year first worked.

‖Referent group for the separate analysis of number of years worked and year first worked.

¶P values were based on the Wald test statistic.

#Analyses were restricted to technologists who were 15–65 years old and therefore eligible for employment in the respective calendar time periods. Analyses were adjusted for employment in other time periods.

subject worked in the following calendar periods—before 1950, 1950 through 1959, 1960 through 1969, and 1970 and later—to reflect potential secular changes in recommended exposure limits *(19,20)*. All statistical tests were two-sided, and P values for tests of trend were calculated based on the estimated slope of the corresponding continuous variable *(18)*.

Among the women included in this study, 75% were born between 1940 and

Table 2. Relative risk* (RR) and 95% confidence interval (CI) of breast cancer mortality (with number of deaths) among the questionnaire respondents†, by year first worked, and number of years worked with specific procedures among radiologic technologists who ever worked with the respective procedures

Year first worked	Total No. of years worked using specific procedure			P_{trend}‡	All years worked
	<10	10–19	≥20		
Fluoroscopy					
1960 or later					
RR(95% CI)	1.0§	1.12 (0.74 to 1.69)	1.13 (0.55 to 2.30)	(.761)	1.00‖
P value¶		.597	.741		
No. of deaths#	61	38	9		108
1950–1959					
RR (95% CI)	1.45 (0.84 to 2.50)	1.42 (0.76 to 2.63)	0.82 (0.39 to 1.72)	(.234)	1.23 (0.77 to 1.95)
P value¶	.182	.269	.592		.384
No. of deaths#	40	21	11		72
1949 or earlier					
RR (95% CI)	1.76 (0.86 to 3.62)	1.65 (0.72 to 3.75)	1.59 (0.73 to 3.47)	.872	1.69* (1.02 to 3.11)
P value¶	.122	.236	.247		.088
No. of deaths#	20	11	14		45
P_{trend}‡	(.067)	(.068)	(.067)		(.068)
All time periods					
RR (95% CI)	1.00‖	1.07 (0.80 to 1.44)	0.83 (0.56 to 1.24)	(.312)	
P value¶		.653	.368		
No. of deaths#	121	70	34		225
Multifilm**					
1960 or later					
RR (95% CI)	1.0§	1.15 (0.76 to 1.75)	1.47 (0.77 to 2.80)	(.850)	1.00‖
P value¶		.514	.249		
No. of deaths⧣	54	39	12		105
1950–1959					
RR (95% CI)	1.63 (0.93 to 2.83)	1.58 (0.85 to 2.94)	1.17 (0.60 to 2.27)	(.380)	1.38 (0.88 to 2.18)
P value¶	.087	.149	.642		.163
No. of deaths⧣	35	20	16		71
1949 or earlier					
RR (95% CI)	2.10 (1.02 to 4.34)	2.53 (1.18 to 5.42)	1.00 (0.41 to 2.40)	(.359)	1.87 (1.04 to 3.34)
P value¶	.045	.017	.997		.035
No. of deaths⧣	16	13	8		37
P_{trend}‡	(.011)	(.011)	(.010)		(.010)
All time periods					
RR (95% CI)	1.00⧣	1.15 (0.85 to 1.55)	0.79 (0.53 to 1.18)	(.151)	
P value¶		.366	.247		
No. of deaths⧣	105	72	36		213
Routine x-rays					
1960 or later					
RR (95% CI)	1.0§	1.10 (0.72 to 1.67)	1.17 (0.63 to 2.19)	(.797)	1.00‖
P value¶		.661	.621		
No. of deaths⧣	45	46	14		105
1950–1959					
RR (95% CI)	1.45 (0.80 to 2.63)	1.25 (0.65 to 2.41)	1.11 (0.60 to 2.08)	(.553)	1.17 (0.74 to 1.85)
P value¶	.219	.497	.734		.511
No. of deaths⧣	29	18	23		70
1949 or earlier					
RR (95% CI)	1.45 (0.67 to 3.14)	1.74 (0.78 to 3.88)	1.28 (0.60 to 2.73)	(.830)	1.37 (0.76 to 2.47)
P value¶	.351	.176	.515		.299
No. of deaths⧣	14	12	16		42
P value‡	(.088)	(.088)	(.088)		(.088)
All time periods					
RR (95% CI)	1.00‖	1.06 (0.78 to 1.45)	0.93 (0.65 to 1.34)	(.487)	
P value¶		.702	.714		
No. of deaths⧣	88	76	53		217

(Table continues)

Table 2 (continued). Relative risk* (RR) and 95% confidence interval (CI) of breast cancer mortality (with number of deaths) among the questionnaire respondents†, by year first worked, and number of years worked with specific procedures among radiologic technologists who ever worked with the respective procedures

| | No. of years worked | | P_{trend}‡ | All years worked |
	<3	≥3		
Radium/other radioisotope treatment				
1960 or later				
RR (95% CI)	1.00	1.01 (0.63 to 1.63)	.798	1.00‖
P value¶		.955		
No. of deaths#	42	29		71
1950–1959				
RR (95% CI)	1.28 (0.71 to 2.32)	1.37 (0.76 to 2.47)	.170	1.28 (0.82 to 2.00)
P value¶	.409	.296		.281
No. of deaths#	19	19		38
1949 or earlier				
RR (95% CI)	1.05 (0.31 to 3.54)	1.30 (0.52 to 3.24)	.680	1.28 (0.62 to 2.65)
P value¶	.938	.569		.507
No. of deaths#	3	6		9
P_{trend}‡	(.114)	(.115)		(.115)
All time periods				
RR (95% CI)	1.00‖	1.07 (0.75 to 1.54)	.581	
P value¶		.699		
No. of deaths#	64	54		118

*All relative risks were stratified for race, attained age, and calendar year of follow-up (latter two are time-dependent) and were adjusted for age at menopause, age at first birth, and family history of breast cancer. The analysis for all years worked was adjusted for the duration of employment using the specific procedure, and the analysis for all time periods was adjusted for the year first worked with the specific procedure.

†We excluded 861 women from this analysis because their questionnaires contained inconsistent values for year of first work and duration of work for specific procedures.

‡P for trend was based on the slope of the corresponding continuous variable; parentheses indicate negative slope estimates.

§Referent group for the joint analysis of the number of years worked and year first worked.

‖Referent group for the separate analysis of number of years worked and year first worked.

¶P values were based on the Wald test statistic.

#Number of deaths is different for the different procedure types because technologists with unknown values and technologists who never worked with the specific procedures are not shown.

**Multifilm procedures included gastrointestinal series, spinal x-rays, kidney-ureter-bladder films, and intravenous pyelograms.

1959, 76% were first certified by ARRT between 1960 and 1979, and 91% were less than 30 years old at certification. The average age at questionnaire completion was 38 years and the average length of follow-up was 12 years. Breast cancer risk was higher (RR = 1.28, 95% confidence interval [CI] = 0.86 to 1.89) among women who were 45 years old or older at menopause than it was among women who were younger than 45 years at menopause, and higher among those who reported having any relative with breast cancer than among those without such a family history (RR = 1.31, 95% CI = 1.00 to 1.72). The risk of breast cancer increased with a woman's increasing age when she gave birth to her first child (RR = 1.28, 95% CI = 0.92 to 1.78 for first births at ages 25 to 29 years and RR = 1.40, 95% CI = 0.92 to 2.14 for first births at age 30 years old or older, compared with women whose first births were at ages younger than 25 years) but was not associated with her age at menarche, the number of live births she had, or the number of mammograms she had received.

The risk of dying from breast cancer was statistically significantly higher for technologists who were first employed prior to 1940 (RR = 2.92, 95% CI = 1.22 to 7.00; P = .016) and for those who were first employed between 1940 and 1949 (RR = 2.44, 95% CI = 1.26 to 4.75; P = .008) compared with those first employed in 1960 or later (Table 1). Risk of death from breast cancer increased statistically significantly (P for trend = .002) with decreasing calendar year period that technologists first worked (Table 1). The duration of employment as a radiologic technologist was not associated with breast cancer mortality in all time periods combined. Nevertheless, breast cancer mortality increased with an increasing number of years worked prior to 1950 (P for trend = .018) (Table 1). The lower breast cancer mortality risk associated with working in more recent calendar periods

may have been due to the effects of adjuvant therapy. However, we could not control for adjuvant therapy effects, because we did not collect data on the use of this form of treatment for breast cancer.

Risks were also higher among women who first worked with fluoroscopy (P = .088) or multifilm procedures (P = .035) before 1950 than among women who first worked with those procedures in 1960 or later. Risk was not associated with first performing routine x-rays (P = .299) or with the use of radium or other isotopes (P = .507) before 1950 (Table 2). Risks were not associated with the number of years that technologists worked with these procedures, either overall or within specific calendar periods. Risk of breast cancer mortality was not associated with the use of lead aprons or the frequency with which technologists held patients who received x-rays. Risks of breast cancer mortality were similar for pre- and postmenopausal women in relation to work practice-related variables.

Breast cancer risks among female Japanese atomic bomb survivors *(1–3)* and among women undergoing repeated diagnostic x-rays *(6,7)* have shown remarkable age-dependence, with risks being highest among women who were younger than 20 years of age at the time of exposure. Most (57%) of the women in our study began working as radiologic technologists when they were between the ages of 18 and 24 years; only 9% began working as radiologic technologists at 25 years old or older (data not shown). Compared with women who began working at age 25 years or older (29 breast cancer cases), the risks of breast cancer mortality for women who began working when they were younger than 18 years, 18–19 years old, and 20–24 years old were 1.46 (95% CI = 0.82 to 2.59; 82 breast cancer cases), 1.39 (95% CI = 0.80 to 2.43; 79 breast cancer cases), and 1.58 (95% CI = 0.93 to 2.66; 65 breast cancer cases), respectively. The limited numbers of technologists who began working before the age of 17 years or after the age of 30 years precluded assessments of the breast cancer risks associated with occupational radiation exposures in these age groups.

This cohort of radiologic technologists is one of the few radiation worker cohorts that contain a substantial number of women *(21–23)* for whom individual information on lifetime work history and cancer risk factors is available. A previous study among 5400 female Chinese medical x-ray workers who were exposed to occupational radiation between 1950 and 1985 found a 50% increase in breast cancer risk compared with hospital workers who were not exposed to radiation; those exposed before 1960 had a 70% increased risk *(21)*. Estimated occupational radiation exposures are likely to have been higher among the Chinese medical radiation workers than among American medical radiation workers during the same time periods *(13)*. Risk for breast cancer incidence was elevated, though it was not statistically significantly higher, among 3404 female Danish medical radiation workers employed from 1954 to 1982 compared with risk among Danish women in the general population *(22)*. However, risk was not higher among 101 164 women (35% of whom were medical workers) in the Canadian national radiation worker registry who were monitored from 1951 through 1983 than it was among Canadian women in the general population *(23)*.

Our study included a long follow-up period, a wide range of work practices, and sufficiently large numbers of technologists, which enabled us to make internal comparisons and thus minimize potential biases due to the healthy worker effect. It is difficult, however, to disentangle the effects of other variables (e.g., year of birth, attained age, and the calendar year of follow-up) that might also affect risk estimates. We performed a similar analysis using breast cancer mortality rates from the U.S. general population to estimate the background risks and found that, although the patterns of risk were similar to those we report here, the risk estimates themselves were somewhat smaller. Our finding—that breast cancer mortality was highest among technologists who first worked in the earliest calendar periods—probably reflects changing exposures to radiation over time. Recommended exposure limits for medical radiation workers decreased from 70 rem/year before 1934 to 30 rem/year in 1934, 15 rem/year in 1949, and 5 rem/year in 1958 *(24)*. This cohort, with its large number of women, estimated wide range of radiation doses received, and the extensive information available on risk factors, is uniquely suited to address the risks of breast and other cancers that are associated with long-term, low-dose radiation exposure.

REFERENCES

(1) Thompson DE, Mabuchi K, Ron E, Soda M, Tokunaga M, Ochikubo S, et al. Cancer incidence in atomic bomb survivors. Part II: Solid tumors, 1958–1987. Radiat Res 1994; 137(2 Suppl):S17–67.

(2) Land CE. Studies of cancer and radiation dose among atomic bomb survivors. The example of breast cancer. JAMA 1995;274: 402–7.

(3) Pierce DA, Shimuzu Y, Preston DL, Vaeth M, Mabuchi K. Studies of the mortality of atomic bomb survivors. Report 12, Part I. Cancer: 1950–1990. Radiat Res 1996;146: 1–27.

(4) Inskip PD. Second cancers following radiotherapy. In: Neugut AI, Meadows AT, Robinson E, editors. Multiple primary cancers. Philadelphia (PA): Lippincott Williams & Wilkins; 1999. p. 91–135.

(5) Boice JD Jr, Land CE, Preston DL. Ionizing radiation. In: Schottenfeld D, Fraumeni JF Jr, editors. Cancer epidemiology and prevention. New York (NY): Oxford University Press; 1996. p. 319–54.

(6) Boice JD Jr, Preston DL, Davis FG, Monson RR. Frequent chest x-ray fluoroscopy and breast cancer incidence among tuberculosis patients in Massachusetts. Radiat Res 1991; 125:214–22.

(7) Doody MM, Lonstein JE, Stovall MS, Hacker DG, Luckyanov N, Land CE. Breast cancer mortality after diagnostic radiography: findings from the U.S. scoliosis cohort study. Spine 2000;25:2052–63.

(8) Cardis E, Gilbert ES, Carpenter L, Howe G, Kato I, Armstrong BK, et al. Effect of low doses and low dose rates of external ionizing radiation: cancer mortality among nuclear industry workers in three countries. Radiat Res 1995;142:117–32.

(9) Muirhead CR, Goodill AA, Haylock RG, Vokes J, Little MP, Jackson DA, et al. Occupational radiation exposure and mortality: second analysis of the National Registry for Radiation Workers. J Radiol Prot 1999;19: 3–26.

(10) Goldberg MS, Labreche F. Occupational risk factors for female breast cancer: a review. Occup Environ Med 1996;53:145–56.

(11) U.S. Environmental Protection Agency (EPA). Occupational exposure to ionizing radiation in the United States: a comprehensive review for the year 1980 and a summary of trends for the years 1960–1985. Kumazawa S, Nelson DR, Richardson AC, editors. EPA 529/1-84-005. Springfield (VA): National Technical Information Service; 1984.

(12) United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources and effects of ionizing radiation. New York (NY): United Nations; 2000. p. 330–4.

(13) United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Ionizing radiation: sources and biological effects of ionizing radiation. New York (NY): United Nations; 1993. p. 426–32.

(14) Boice JD Jr, Mandel JS, Doody MM. Breast cancer among radiologic technologists. JAMA 1995;274:394–401.

(15) Doody MM, Mandel JS, Lubin JH, Boice JD Jr. Mortality among United States radiologic technologists, 1926–90. Cancer Causes Control 1998;9:67–75.

(16) Boice JD Jr, Mandel JS, Doody MM, Yoder RC, McGowan R. A health survey of radiologic technologists. Cancer 1992;69:586–98.

(17) World Health Organization (WHO). Manual of the international classification of diseases, injuries, and causes of death, 9th Revision. Geneva (Switzerland): WHO; 1977.

(18) Breslow NE, Day NE. Statistical methods in cancer research. Vol II—The design and analysis of cohort studies. IARC Sci Publ 1987;(82):1–406.

(19) Spalding CK, Cowing RF. A summary of radiation exposures received by workers in medical x-ray departments from 1950–1960. Health Phys 1962;8:499–502.

(20) Roessler CE. Management and administration of radiation safety programs. Madison (WI): Medical Physics Publishing; 1998. p. 9–11.

(21) Wang JX, Inskip PD, Boice JD Jr, Li BX, Zhang JY, Fraumeni JF Jr. Cancer incidence

among medical diagnostic X-ray workers in China, 1950 to 1985. Int J Cancer 1990;45: 889–95.

(22) Andersson M, Engholm G, Ennow K, Jessen KA, Storm HH. Cancer risk among staff at two radiotherapy departments in Denmark. Br J Radiol 1991;64:455–60.

(23) Ashmore JP, Krewski D, Zielinski JM, Jiang H, Semenciw R, Band PR. First analysis of mortality and occupational radiation exposure based on the National Dose Registry of Canada. Am J Epidemiol 1998;148:564–74.

(24) Inkret WC, Meinhold CB, Taschner JC. Protection standards: radiation and risk—a hard look at the data. Los Alamos Sci 1995;23: 117–24.

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